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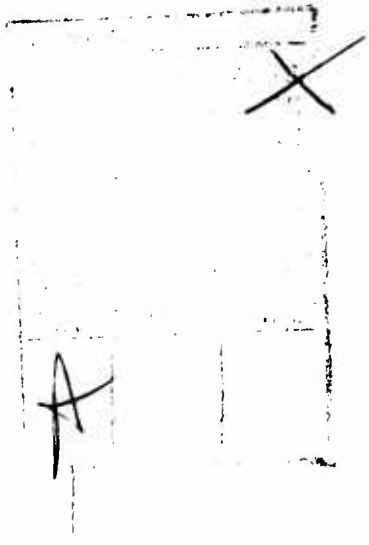

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ON THE STRINGENCY OF DOSAGE CRITERIA FOR BATTLEFIELD NUCLEAR OPERATIONS

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There appears to have been a tendency by U.S. military analysts to treat the matter of initial nuclear radiation dosages--for battlefield nuclear operations--in relatively narrow terms. The major emphasis has been placed on dosage criteria for the production of a specified reduction in combat effectiveness, for relevant military tasks, within a given period after exposure. This has taken the form of determining a single dosage to describe the radiobiological effectiveness of a tactical nuclear weapon.

The requirement for this dosage is that it produces a severe performance degradation within a short time after exposure and that the effect represents a specific human response--i.e., permanent combat ineffectiveness. Such factors as transient incapacitation; delayed casualties and fatalities; less than severe performance degradation; and performance degradation resulting from synergistic relationships between weapon effects have not been given serious or adequate attention.

Moreover, and this perhaps represents the key deficiency, this requirement has been analyzed with but little regard to the relationship between exposed personnel and the operational environment in which they may operate. What does not seem to have been given sufficient recognition are such factors as: the identification of personnel with a given side in the conflict; the relationship of these personnel to the broad nature of the conflict; and the driving operational factors stemming from their side's doctrine. In this respect, the assessment of U.S./NATO attacks on Soviet/Warsaw Pact units has been essentially a mirror-imaging process where the results of such attacks have been predicated around our view of the other side's capabilities rather than how the other side may view them--based on his doctrine, strategy, and plans. This seems fallacious.

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*This Paper is drawn from a presentation given to the Tactical Nuclear Warfare Working Group during the 34th meeting of the Military Operations Research Society, at Fort Eustace, Virginia.

With respect to battlefield situations where initial radiation is the primary nuclear weapon effect, to date the problem has been treated in a highly constrained, and even artificial, fashion. Soviet army units have been assigned fixed dimensions and weapon effectiveness has been assessed on a "cookie-cutter" coverage basis, selecting a particular dosage value on which to base the calculation.

Regarding the relationship of the attacked enemy units to the hypothetical conflict situation being analyzed, the operative scenario which would determine the consequences of such attack calculations has not been fully addressed. Nor have the political factors which, at least from a NATO standpoint, may be of cardinal importance in dictating the use of NATO's tactical nuclear weapons.

Needless to say, the relevancy of required dosage levels which relate directly to the problem of weapon effectiveness is very sensitively related to the envisaged scenario. And this relevancy poses a number of key questions:

What time frame are we concerned with? What capabilities on each side exist in this time frame? How does the conflict begin? How are both sides postured? What are their strategies and tactics? How long does the war last and does it last long enough to bring delayed effects (from initial radiation dosages) into important perspective?

Admittedly, these are questions which hardly have precise (or, in some cases, any) answers. But if they are not addressed, we run the risk of considering the problem in an incomplete and unrealistic manner.

Any given scenario for nuclear war in NATO may be as indefensible and spun from whole cloth as any other. Nevertheless, since the military and political factors which are attendant to these hypothesized events can have a vital bearing on the meaning and implications of "radiation kill" criteria, it behooves us to address this issue (of initial radiation effects) in this broader context.

One might infer, from this foregoing discussion, that the problem of initial radiation dosage criteria, in itself, is not of first-order importance in view of the many intangibles surrounding it. To the contrary, it is a highly important problem, since its resolution relates directly to the matter of nuclear warhead requirements. For what is

at issue here, in view of increasing political constraints on the employment of battlefield nuclear weapons, is the credibility of NATO's future tactical nuclear stockpile.

Starting at the broadest level, we shall consider the problem of possible conflict scenarios for NATO and how the specific issue of dosage requirements is affected by such consideration.

For more than a dozen years, the prevailing U.S./NATO assessment has been that the most probable (but still extremely unlikely) Soviet attack against NATO will be non-nuclear. The tactical nuclear initiative is assigned to the West; and, even were such use to be made by NATO, the expectation is that, rather than risk an escalatory nuclear conflict, the Soviet reaction most probably would be to seek conflict termination. In terms of this assessment, the Soviets are essentially denied the opportunity to most effectively use their battlefield nuclear weapons.

Illustrative of this assessment is the following exchange between Senator Symington and General Goodpaster, which took place during Senate hearings last year:

> *Sen. Symington:* If we replied to a Soviet conventional attack by using tactical nuclear weapons, have you any doubt that they would immediately start using nuclear weapons themselves?
>
> *Gen. Goodpaster:* I don't concede at all that they would. They might. But they would have to ask themselves the question that I referred to earlier and that is--what is there west of the Iron Curtain that would justify entering into a process of escalation that could involve an attack on their own homeland?
>
> *Sen. Symington:* Certainly they might. Is it your opinion that they probably would not?
>
> *Gen. Goodpaster:* My opinion is, and this is, of course, completely speculative--
>
> *Sen. Symington:* It is very important, though.
>
> *Gen. Goodpaster:* Yes, indeed.
>
> *Sen. Symington:* It couldn't be more so.
>
> *Gen. Goodpaster:* In the context that we are talking about, a large-scale, non-nuclear attack against Western Europe, if we were to apply in a controlled way limited numbers of nuclear weapons sufficient simply to stop the attack

> and impose costs and losses on their attack echelons, my own feeling is that the probabilities would be much less than even that they would immediately carry that to all-out nuclear exchange involving their own homeland.
>
> *Sen. Symington:* In other words, your testimony before this committee is that we could use nuclear weapons in Europe and that the Soviets, in all probability, would not respond to nuclear weapons?
>
> *Gen. Goodpaster:* I would not go so far as to say in all probability. I think you have to think probabilities, but I think there is an appreciable probability that they would not.

Against this backdrop, not only is the radiobiological problem, and its relationship to the effectiveness of NATO's battlefield nuclear weapons, extremely difficult to assess, but so is the cogency of NATO's battlefield nuclear arsenal--its size and its composition. This difficulty stems from the fact that these initial (and limited) nuclear strikes are basically political in nature and are viewed as representing more a display of intent and resolve rather than a military means to halt the Soviet/Pact advance.

In this political context, the military effectiveness of NATO's use of battlefield nuclear weapons comes primarily from a Soviet political assessment rather than a comprehensive evaluation of the military damage they have suffered. As a consequence, it is not possible to meaningfully relate the problem of initial radiation dosage levels to the immediate military outcome of these strikes; nor, for that matter, is it at all clear that, technically speaking, the radiobiological problem is at all a relevant component of the military issue.

This scenario for possible use of battlefield nuclear weapons not only pre-supposes salutary results for NATO but mainly ignores the details of use. And, moreover, it essentially rejects the possibility that extended (in time), limited (in geography) tactical nuclear conflict may ensue as a result of NATO's initial use; thereby also rejecting the implications of the longer range radiobiological effects.

On the other hand, since this scenario is primarily politically dominated, there is one political aspect of this problem which does bear on the issue of "radiation kill"--namely, collateral damage.

Specifically, the collateral damage constraints which NATO places on the employment of its battlefield weapons do appear to relate importantly--albeit indirectly--to the criteria affecting short-term radiation effects. For assuming that initial radiation is accepted as a basic kill mechanism for target neutralization, NATO's desire to avoid large levels of collateral damage now bears on the judgmental problem of what dosage levels are considered adequate--so that weapon use becomes permissable--rather than what dosage is required to permit effective use. This distinction between "permissable" and "effective" (a term more readily defined than determined) use, which we shall address later, is the real guts of the matter.

Although the scenario just described continues to hold official acceptance by NATO, there is a body of opinion which takes the view that first use of nuclear weapons--regarding a NATO/Pact conflict--will be made by the Soviets. Furthermore, this viewpoint contains the belief that such use will take place at the very beginning of the conflict, thereby providing the Soviets with the very substantial advantages of exploiting NATO's peacetime vulnerability to nuclear attack.*

Considering NATO's continued high vulnerability to surprise nuclear attack, were this mode of attack to be the preferred Soviet option, the irrelevance of initial radiation dosages would be apparent from essentially the very beginning of a conflict which began in this manner;

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*This viewpoint has been shared in the past by Henry Kissinger, who, during the mid-1960s, stated:

> "Considering the extreme vulnerability of the tactical nuclear establishment on the Continent and the fact that the Soviets would not attack without expecting to win...If there is large-scale aggression...the Soviets have every incentive to neutralize NATO's nuclear arsenal by launching an attack against it." *The Troubled Partnership*, McGraw-Hill Book Co., 1965.

It has also been espoused by former British Defense Minister, Denis Healey, who declared several years later:

> "...the other side would use nuclear weapons to begin with, and there's a great deal of evidence for that, both in the exercises they do and what they write in their strategic journals." *The Nuclear Genie*, Interview, Radio 4 (London), 7 April 1970.

for most probably, the beginning would also be the end insofar as prospects for effectively using NATO's battlefield nuclear weapons were concerned. To deal realistically with the problem of Soviet first-use, NATO would have to undergo a drastic reposturing--with a correspondingly drastic change in doctrine and strategy affecting the use of tactical nuclear weapons--to ensure a survivable force capable of conducting battlefield nuclear operations.

Were such change ever to take place, a scenario for conflict in NATO would be extremely difficult to envisage. Under such circumstances, one would be contemplating tactical nuclear conflict where both adversaries presumably had postured themselves to allow effective strategies and tactics; and, for this mode of conflict, where no basis of experience exists, the dynamics of battlefield operations and their relationship to something as exotic as initial radiation dosages literally boggles one's imagination.

For this future situation (which currently is very difficult to conceive), perhaps the only pertinent remarks regarding initial nuclear radiation effects would, once more, have to do with collateral damage constraints (which seem reasonable to project into the future). And were such conflict to last over an appreciable period of time, the problem of delayed effects would become relevant.

Against this highly uncertain scenario backdrop, we shall now attempt a limited resolution of the dosage requirements matter.

In a Western European conflict setting, the problem of dosage requirements--to achieve certain desired effects in combat units--would, in principle, appear to involve consideration of both NATO and Warsaw Pact forces. However, realistically speaking, we cannot practically examine this problem on the basis of Soviet nuclear attacks against NATO combat units, for this is an issue which must be resolved from the Soviet side.

Whereas the open Soviet military literature indicates a decided interest (and even a preference) in "radiation kill," it provides little to indicate how they might assess the radiation vulnerability of NATO forces.

Therefore, the truly relevant problem regarding dosage requirements has to do with attacks against Soviet/Pact forces. And, in this respect, what can be said about the initial radiation dosage levels as they pertain to the neutralization of Soviet/Pact units?

Toward addressing this question, it should be noted that the problem of battlefield nuclear weapon effectiveness and its relationship to the weapon selection process has, to date, been handled very much differently from the conventional case.

In conducting conventional attacks against enemy units, the experience, to date, has been that such attacks usually have been made with no reliable expectation of results in advance. Instead, available conventional firepower has been applied against located (or even suspected) enemy units until a determination (or intuition) could be made on the results of the attacks. Broad experience in conventional conflict indicates that when unit casualty levels approach 20 or 30 percent, the unit ceases to be combat effective.

So, even though the conventional experience has involved dealing with "familiar" weapon effects against enemy personnel, our actual utilization of anti-personnel weapons hardly has entailed any accurate predictive capabilities. The design features of such conventional ordnance have been based far more on the technical requirement to maximize weapon effectiveness than on a requirement for weapon effectiveness based on specific expectations of combat performance.

On the other hand, in the area of battlefield nuclear weapons, essentially the opposite procedure has taken place. The nuclear battlefield situation (for which we have no realistic basis of experience) has been rigorously depicted and enemy units have been assigned specific frontages and depths to allow weapons coverage calculations to be made. And, even though the effects from nuclear weapon attacks are drastically different from the conventional case--in their nature, in their homogeneity of application, and in the time of application--the coverage requirement for unit neutralization has been strongly conditioned by the conventional experience.

Toward applying the radiobiological data base to the coverage calculation problem, the dosage requirement has been predicated, so far, on the need to achieve a severe performance degradation within a short time after exposure. In addition, the calculation has been made on a "cookie-cutter" basis, and no serious attempt has been made to relate the reactions and functions of those beyond the cookie's edge to those within.

On the radiobiological side of the house, the input to the problem has been primarily a response, based on animal experiments, to queries seeking initial radiation dosage levels which will produce permanent casualties to a specified percentage of the affected population and within a prescribed period after exposure (i.e., 15 minutes, one hour, four hours, etc.). In this respect, the radiobiological faction has sought, as best possible, to provide the requested data. However, in requesting this data, it is far from clear that the user has related significantly to the broad operational and political realities of the problem. In fact, as mentioned earlier, the user has not; and, instead, has elected to "solve" the problem within the narrow confines of analytical solutions to hypothesized local military problems.

That "War is an art, not a science" has been generally accepted by those who have commanded forces in conventional conflict. However, if non-nuclear battlefield conflict is adjudged to be an art, then nuclear conflict, having no base of actual experience, can only be described as mythology (or something even more ethereal) let alone a science. Yet, as alleged here, the subject of tactical nuclear weaponry has, in the main, been treated in highly scientific form by the military and the "judgment" factor, deemed to be so critical in assessing conventional war matters, seems to have been mainly discarded. This has been particularly true in the area of radiobiological effects.

In addition to the military "judgment" factor, there have been two other areas not receiving adequate or proper consideration: (1) the enemy--who is treated mainly as an animal subjected to U.S. radiobiological experimentation, rather than for what he may actually be, and whose units have been assigned dimensions that are most unlikely to materialize; and (2) the politics surrounding (and perhaps even

governing) the use of NATO's battlefield nuclear weapons.

Granting the desirability to neutralize a highly mobile Soviet combat unit within a time shorter than that required for this unit to advance upon a NATO defensive position, at the same time--when considering initial radiation dosages required to accomplish this end--is it both necessary and sufficient to regard this objective solely in terms of producing some degree of performance decrement? Going one step further, is it sufficient to regard performance solely in terms of the ability to operate weapons and equipment or should performance also be related to coping with attendant damage to weapons and equipment?

Whereas we do not know, in detail, how the Soviets view "radiation kill" criteria, as brought out earlier, there are indications that they place considerable importance on this kill mechanism for battlefield attacks. It would follow, then, that toward planning on what responses to take in the event of nuclear attack against their units, the Soviets have given considerable thought to the criteria (not necessarily as we would view them) for determining whether or not a unit has been effectively neutralized and should be replaced. (The Soviets seem to have held to a unit replacement policy, although, in their military literature, the utility of this practice for battlefield nuclear operations has been questioned.)

In this sense, would the Soviets assess the criteria problem basically in terms of target coverage involving radiation dosages which would produce specified performance decrements? Or might they tend to view the matter in the broader terms of what damage--biological and material--the unit appeared to have suffered and the consequences of such damages to the operation at hand? Whereas we cannot choose between answers to these questions, if one examines the Soviet doctrine for tactical nuclear operations, the indications are that the latter question more likely would apply.

As is well-known, Soviet doctrine calls for highly mobile offensive operations in what is expected to be a rapidly moving and changing environment. The plan (anticipating success against NATO) calls for advances of several tens of kilometers per day, with the expectation

being that the war's duration will be only on the order of a week. The achievement of strategic objectives will be attained through a single high-speed, continually moving operation rather than a series of advances involving pauses for regrouping and recovery.

An offensive strategy of this nature would seem to be intolerant of disruptions which might result in significant holdups of the advance. In this vein, we have such statements as:

> "Loss of speed in an attack or halting of a tank under direct enemy fire, is tantamount to its destruction..." *Antitank Warfare*, Maj. Gen. G. Biryukov and Col. G. Melnikov, Soviet Army.

> "The mutual employment of nuclear weapons, the high mobility of the troops, and the great saturation of the battlefield with tanks will lead to rapid and sudden changes in the course of the offensive. If, in the last war, no substantial changes in the situation usually occurred during an hour...now the situation on the battlefield changes by minutes and even seconds...not only quickly but suddenly..." *The Offensive*, Col. A. A. Sidorenko, Soviet Army.

Allowing for the dramatic style which pervades Soviet military literature, still there seems to be a strong inference that the disruption factor relates importantly to the determination of unit effectiveness. In this sense, an attack where dosage levels on the order of, say, 1000 rads produced--within a short time after burst and intermittently thereafter, for a number of hours--transient incapacitating effects might suffice approximately as well as one where the target coverage and response was determined on the basis of dosages an order of magnitude higher.

Long considered, but generally dismissed because of an inability to make any deterministic assessments, has been the psychological factor associated with the problem of nuclear radiation--both initial and delayed. However, if the problem has been unfathomable on the U.S. side, it has been deemed crucial on the Soviet side; and, in this respect, it would seem to deserve renewed consideration and judgment on our side.

> "In modern war, numerous factors will influence the feelings and mental state of the soldiers and commanders.

> Above all, the personnel will be under the influence of high combat spirit and a profound awareness of the necessity to quickly and successfully carry out the combat missions. At the same time, under a situation of the use of nuclear weapons, we must not exclude the possibility of temporary shock and the appearance of feelings of fear and uncertainty..." *On Guard for Peace and the Building of Communism,* Soviet Defense Minister, A. A. Grechko.

> "In determining the effect of nuclear weapons on the nature of the offensive, consideration should be given not only to the materiel damage inflicted directly by it, but it is also mandatory to consider the tremendous morale and psychological effect on the personnel...The soldiers who have survived the nuclear strikes...will constantly think about the dangers of radioactive irradiation. This unseen danger of irradiation and ignorance may cause a sense of alarm, fear, and excited state, and passivity in actions which will lead to reduction in the combat qualities and activity of the personnel." *The Offensive,* Sidorenko.

While Colonel Sidorenko's remarks appear to apply to delayed radiation, from their nature one could safely infer that very similar observations would have been made for those exposed to initial nuclear radiation. In fact, for those receiving sufficient irradiation to bring out radiation sickness symptoms (the so-called "prodromal" syndrome), it would seem that the psychological manifestations, catalyzed by all the other effects--flash, dust, accoustical, earth shock, etc.--would be significantly greater. For this case, the morale factor has to do with what is known to have happened, rather than what might happen or might be happening: The individual's crisis (the nature of which he cannot comprehend if the dosage he has received is in the lethal and supralethal range) is at hand--not impending.

The argument long has been made that an awareness of mortal consequences (made possible by individual dosimetry in Soviet personnel, or by perception of their physical distress) may turn a substantial number of those exposed into temporary heroes. In fact, it is argued there may be more heroes produced than cowards (if the term applied for such conditions); and, for those cases where a considerable amount of time goes by before permanent ineffectiveness sets in, the heroes will succeed in producing a level of unit combat effectiveness transcending the case where the unit was not attacked.

To this contention, two comments are in order: (1) Even though, as Marshal Grechko would anticipate, the Soviet soldier might be patriotically impelled to perform to his utmost under such traumatic conditions, it is far from clear that Soviet tactical nuclear doctrine allows any exploitation of the "hero-factor": the hero may be constrained by doctrine to perform no better than before his radiation-induced heroification took place; and (2) If Marshal Grechko's requirements for morale and dedication are met--through training and indoctrination--the heroification process may have reached asymptotic proportions before irradiation.

In view of these considerations and assuming--despite the high motivation of the Soviet soldier--that some fraction of those affected will suffer psychologically-induced degradation in effectiveness, it would appear then, on balance, the morale factor (regarding initial radiation exposures) may be negative. Therefore, for non-incapacitating dosages, one can expect (intuit) that there will be a psychological bonus coefficient multiplying whatever the biological effects may be. Thus, we note another factor giving added emphasis to the military relevance of dosages an order of magnitude below those which, in recent years, have been proposed to fulfill the quick incapacitation requirement.

Dosage requirements to produce given decrements in combat performance have (fallaciously) been predicated on the assumption that the specific task at hand will remain the same after the irradiation has occurred. For example, the resulting performance decrement for, say, a tank crew carries the premise that the tank and its associated equipment is not significantly affected at distances where relevant dosages accrue. Depending upon the nature and yield of the nuclear weapon used, this simplifying assumption may or may not be credible. And where it is not credible, to assess the importance of a given dosage level, it becomes necessary to consider the problem of performance decrement on a combined-effects basis.

As viewed in U.S. tactical nuclear planning, the criteria for light and moderate damage have been based on the expectation that repair and replacement facilities will be readily available on the tactical

nuclear battlefield, as has been the case in conventional conflicts where U.S. forces were involved. No effort was made to relate these criteria to the conditions of the nuclear battlefield. Moreover, it would appear that the bases for these criteria have been projected to Soviet forces--despite all indications that no such convenience of repair and replacement seems to be a part of the Soviet nuclear battlefield capability. This gives rise to the prospect that those Soviet personnel who operate weapons and equipment may have to deal themselves with damage to these items while in the throes of radiation sickness. For such situations, the dosage criteria may more immediately apply to a repair function rather than an operating function. Or, if repairs are not readily in order, the operating of weapons and equipment may become a more difficult task.

(The neglect of this combined-effects factor is rooted in the low priority given to tests of damage to Army materiel during the 1950s. Such tests considered the exposed materiel essentially as structural entities, rather than operational tactical configurations. As such, ammunition, radios, and other gear were not in attendance and vehicles were stationary--engines off, brakes on, and no gas.)

For a fission yield of several KT, light damage to tracked vehicles and self-propelled artillery (breakage in optical equipment, destruction of whip antenna) and a crew dosage on the order of 1000 rads occur at roughly the same distance from ground zero. Also at this yield level, light-to-moderate damage to wheeled vehicles (glass breakage, some engine damage, undercarriage damage, possible overturning) and 1000 rads result at about the same distance. For more sensitive equipment--such as radar antennae and radomes--these observations may hold true at the one KT level and below.

As brought out before, one cannot evaluate the dosage requirement problem purely in terms of the perceived military dictates. For nuclear war in Western Europe, the matter of collateral damage has increasingly assumed more crucial proportions; and, as a consequence, the constraints on the employment of battlefield nuclear weapons have been increasingly tightened. Thus, if one assumes that the original weapon selection process properly reflected the military needs, the

conclusion could be drawn that these tightened constraints have produced a potential reduction in military effectiveness.

So far, although collateral damage has been of mounting concern, there has been no set of criteria to define this issue in terms of acceptable levels of civilian casualties and structure damage. Nor is it likely that such criteria will emerge in the foreseeable future, since the issue has highly emotional underpinnings--entailing considerable political risk in establishing formal procedures for the use of weapons whose possible use is generally eschewed by the West German government and people.

On the other hand, if we are not likely to gain a quantitative resolution of the collateral damage problem, clearly the possibility for using battlefield nuclear weapons will be seriously affected by this concern. In turn, the weapon yield will be a critical factor and, where "radiation kill" is the dominant effect, the required yield will be directly proportional to the required dosage. In this vein, the problem of required dosage has to be viewed pragmatically, in terms of balancing the associated political and military requirements. And one should keep in mind, considering NATO's present nuclear employment policy that, in principle, the politician can veto the military's request.

Since the risk involved, regarding NATO's battlefield nuclear weapons, is not that the required coverage of a Soviet unit will not be achieved (if too low a dosage value--and, thus, too low a yield--is used for weapon selection), but rather that the request for use may be denied, what seems suggested here is that the military judgment should opt toward accepting lower dosage values than are currently held to be required. However, such judgment might be viewed with alarm by some as having unduly compromised the military effectiveness side of the equation. This, in turn, brings up the question dealing with how realistic the weapon selection process has been.

There are reasons to believe that this process has been overly conservative--from both the standpoint of weapon effects and requirements for target coverage. For these reasons, if nothing else changed in this selection process but a reduction in dosage requirements, the

military risk involved (if, indeed, there is one) still would be compensated for very substantially.

With respect to target coverage and its relationship to the weapon selection process, there is an additional aspect of the problem which deals both with the efficacy of the process and the dosage requirement--namely, the relationship between the "real world" target (in actual combat) and the target we hypothesize in peacetime in order to make the selection. To this point, there are no indications that the Soviets plan to present us with the target arrays we have assumed for our calculations. Again, referring to Sidorenko's *The Offensive*, the following statements are made:

> "With the acceptance of nuclear weapons into the arsenal of armies, a tendency is clearly observed for expansion of the zones of advance. Now the battalion is assigned the same front of advance in which a division operated in the years of the past war.
>
> "...It is impossible to determine the width of a front of attack purely arithmetically, without consideration of the concrete conditions of the situation. The size of the front of attacks depends not only on the composition of friendly forces, the nature of the defense, and density of enemy man and materiel, but also on the other factors and, above all, on the use of nuclear weapons...
>
> "...It is impossible to win a battle just by dispersal alone. A reasonable compromise must be found here between the requirements for troop protection and the need for successful accomplishment of the combat mission."

How the Soviets may solve the vulnerability problem posed by Col. Sidorenko, this solution is not in the U.S./NATO province to decide. However, these statements plainly indicate that Soviet target arrays may be very much different from the U.S.-hypothesized model; and, granting the Soviet commanders some independence of thought and action, it is most doubtful that they would present arrays which will give any credence to the U.S. weapon selection process. For the Soviets to give such credence would be ensuring that highly effective attacks would be made against their units. This might be most generous on their part but their prudence would be something else.

In making "a reasonable compromise...between the requirements for troop protection and the need for successful accomplishment of the

combat mission," a critical factor in the Soviet determination would be their (not our) assessment of the dosage requirement. And since it is fair to assume that the Soviets have good information on the yields of U.S. warheads, plus delivery system performance (most of these data are already in the public domain), they would probably want to structure their unit deployments on a basis which minimizes U.S. weapon effectiveness. In this case, what initial radiation dosage would they plan upon?

Whereas we cannot realistically determine this for the Soviets, even were we to do so this would be essentially a fallacious process, since we would be approaching the matter (as we have done, thus far) on *our* set of risk factors--relating to the success of *our* nuclear use; rather than on *their* set--which involves the possible destruction of *their* units. To minimize our risk, we prefer to bank upon the higher dosage values; but, for the Soviets to minimize their risk, they have to worry about the lower values. So, from this standpoint, there may be some logic in pegging the dosage level to those which the Soviets more likely are more concerned with. And, as discussed previously, the Soviet doctrine seems to lend support to the importance of these lower levels.

How far the Soviets might disperse their units (to reduce vulnerability) before combat effectiveness is reduced below some tolerable threshold, this, in view of the imponderables associated with tactical nuclear warfare, is not very amenable to quantitative analysis. On the other hand, it is pointed out that--where initial radiation effects are the dominant damage factor--yield requirements rise relatively steeply with increases in target dimensions.

As discussed by Col. Siderenko, Soviet dispersal policy, for "nuclear scared" conditions, relegates the vulnerable unit (for attack by a single weapon) to the company level. At this unit level, distances between combat vehicles (tanks and APCs) are held to be "most favorable up to 100 meters." On this basis, for a company, the front of attack would be on the order of one kilometer.

These dimensions suggest fission yields on the order of one KT, to gain respectable weapon coverage, if the dosage requirement is 10,000 rads. (For a requirement of 1000 rads, the yield goes down by an order of magnitude.)

However, taking into account Col. Sidorenko's remarks on dispersal, should a Soviet commander elect to move his tank company forward with spacings 50 percent greater than those held to be "most favorable," for 10,000 rads the required yield would increase to the order of 10 KT. (For 1000 rads, the yield would increase to about one KT.) At 10 KT, though, serious collateral damage problems may exist; and the Soviets, to reduce their own vulnerability to nuclear attack, might have succeeded in reducing it to zero if the U.S./NATO military requirement held firm and thereby evoked political disapproval of the strike. So, in principle, one notes that the exigencies of the battlefield situation may present targets whose attack may not receive political sanction if an insistence on high dosages (~ 10,000 rads) is made.

Combat unit areas are not necessarily constrained to rectangular geometry. For example, a commander might elect to disperse his tank company in donut form where the radius substantially exceeded the radius conforming to a permanent incapacitation dosage--i.e., ~ 10,000 rads. In this case, for a central burst, the target area coverage might well conform to a much lower dosage--i.e., 1000 rads--if it were politically inappropriate to employ a much higher yield.

To what degree and in what geometry Soviet units might actually disperse, before the commander decided his unit effectiveness had decreased below some tolerable threshold, this is not a resolvable problem. However, it would seem prudent to assume that dispersal will take place to negate the effectiveness of nuclear attacks; and, to this point, the potential advantages of Enhanced Radiation (ER) warheads comes into focus--ER warheads having the same radiobiological effectiveness as fission warheads having an order of magnitude greater yield.

Substituting ER for much larger yield fission warheads not only sharply reduces the level of structual collateral damage but also presents the opportunity to achieve very large reductions in civilian casualties. This latter possibility stems from the ability of the civilian populace to take simple civil defense measures--namely, shielding against initial radiation. In this regard, such measures will become more feasible if the military dosage criterion is on the order of, say, 1000 rads instead of 10,000 rads.

Finally, toward pleading the case for acceptance of lower dosages, let us turn to the matter of delayed casualties resulting from initial radiation effects.

In the context of present U.S./NATO policy, it is extremely difficult to conceive of extended tactical nuclear conflict for two reasons: (1) the U.S./NATO aversion to any use at all is great, and any use most probably would be a limited release--over a very brief period--to show resolve and impress upon the Soviets the risks of extending the conflict; and (2) the Soviets are expected to, most likely, back away in the face of such resolve and seek conflict termination and, if they don't, the war will quickly escalate to strategic proportions--thereby rendering battlefield operations relatively meaningless.

From the Soviet viewpoint, the difficulty in imagining extended conflict would seem to stem from the Soviet doctrine calling for a blitzkrieg nuclear offensive which would bring the campaign to an end within a week or so and achieve its basic objectives within an even shorter period: a far shorter period if the war begins with a Soviet nuclear attack. Considering NATO's present inadequacies, vulnerabilities, and lack of tactical nuclear doctrine, the Soviet expectation hardly seems unreasonable.

For reasons such as these, in addition to considerations of near-term effects arising from massive dosages, the problem of delayed (days to weeks) deaths, after initial radiation exposures in the range of hundreds to thousands of rads, would seem largely academic insofar as its relationship to the military outcome. However, there are other reasons for giving serious consideration to this matter.

First of all, even in the current NATO/Pact context, whatever attitudes and expectations may now be, wars have a habit of rarely reflecting pre-war opinions on their nature and duration. Thus, one cannot rule out the possibility of a war lasting long enough to give credence to concerns over delayed deaths.

Next, one also cannot rule out the possibility that changes in policy and doctrine will occur on NATO's side, leading to a nuclear emphasis posture for NATO which holds planning factors based on nuclear conflict of duration approaching that presently anticipated for large-

scale conventional conflict in Europe. (Also, although it has been very unfashionable to contemplate nuclear conflict in some other part of the world, this possibility cannot be excluded, and it may be of considerable duration.)

Moreover, there is more than just a military outcome to a war. For a "radiation" war, in particular, there will be medical problems resulting from delayed casualties and deaths which, in their nature and magnitude, are unique in the annals of warfare. The importance of these problems--which will materialize whether the war is long or short--can be great, indeed, for they raise medical issues--functional and moral--which have no precedent and which, to date, there has been an ostrich-like tendency to ignore. Should large-scale tactical nuclear conflict ever occur in the future, the uniquess of the radiobiological facet may present a "future shock" in the post-war period.

Finally, in a philosophical vein, there is the issue of "uncertainty" which pervades any nuclear conflict--near-term or long-range. In this vein, it behooves one to consider the relevance of any factor whose significance looms as a possibility.

Perhaps the most cogent aspect of this delayed effects issue is the significant fraction of the total number of fatalities who may survive over hours, days, and weeks prior to death as viable combat personnel. Even on the basis of a unit replacement policy, there still will be dramatically new and different problems--quite possibly of great proportion, posing operational questions never of relevance in conventional warfare and, thus far, not seriously addressed in planning for tactical nuclear combat. These problems will begin with how and when to make this replacement decision; will continue, and perhaps even amplify, as affected units begin a "Death March" toward the rear; and will raise medical questions, when the withdrawal is completed, which, as of now, seem barely addressable, let alone answerable.

As discussed earlier, the Soviets seem to be highly sensitive to the morale problems arising from nuclear radiation effects. In this sense, the effect upon the survivors who observe those entering the period of debilitation before death is something which seems more out of science-fiction than a matter for sober military consideration. In

addition, the second-hand accounting of troops going through these throes may have profound effects on the morale of those who, thus far, have not been so-victimized.

Aggravating and intensifying the delayed effects problem is synergistic damage from initial radiation, blast, and heat. To some (unpredictable) extent, injuries will result from the latter two effects, and the ability to cope with these injuries can be significantly degraded by the accrued radiobiological damage.

Radiation exposure can seriously effect blood clotting functions. Therefore, blast-produced injuries leading to significant bleeding could lower resistance to infection, and thermal burns could be considerably more dangerous than if they were produced in the absence of nuclear radiation.

Regarding unit deployments, it is pointed out that the calculations for delayed casualties have, thus far, assured a uniform distribution of personnel over the area occupied by combat units. In the "real world," of course, such uniformity is rarely the case; and, in all probability, the nature of deployments on the nuclear battlefield will act to enhance the significance of delayed casualties, as units--i.e., companies--disperse to reduce the number of high-level exposures.

Unlike the convenient uniform distribution case, the real world case involves units whose dimensions are continually changing and, therefore, there is no idealization of a "typical" deployment which can be conveniently assumed. However, in the unpredictable movement of a Soviet maneuver unit, there may be situations where considerably more personnel are in the range of dosages having delayed effects significance than those corresponding to prompt casualties.

As to how well (more importantly, how willingly) NATO might engage in tactical nuclear conflict with Soviet/Pact forces, this is a matter of highly subjective opinion. However, as to how well prepared NATO may be for such conflict, clearly from many standpoints the answer has to be *poorly;* but most poorly is the doctrinal/strategy area where little of substance has been accomplished toward dealing with the major issues affecting battle outcome and conflict termination. And one such issue would seem to be that of delayed casualties.

If the delayed casualties issue is considered to be important, the relevance of initial radiation dosages on the order of 1000 rads increases accordingly. Therefore, in addition to the case made here for giving more serious attention to this dosage level in connection with short-term combat ineffectiveness, the delayed casualties case may serve to sharpen such attention.

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